PHOTOLUMINESCENCE IN $ZnGa_2O_4$

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$ZnGa_2O_4$ compound has been prepared by a simple method of ceramic sintering. Its photoluminescence (PL) spectra have been studied using laser beam excitation (λ = 334 nm) at 295 and 10 K. A blue-green long wavelength radiation band has been found out with the peak at 480 nm as well as a series of intensive narrow PL peaks centered at 687, 695, 708 and 714 nm (T = 295 K). The first band may be due to the defect material structure or the ZnO trace amount presence. The sharp peaks may appear due to impurities of rare-earth elements.

Introduction

Wide-gap semiconductor compounds $A^{II}B^{III}{}_2C^{VI}{}_4$ are promising materials for application in light-emitting devices involving lasers for visible range [1], photoelectric UV-detectors [2], wide-range photovoltaic devices [3]. They can be also used for solar energy conversion [4,5]. Among them nanostructure materials and materials with layered crystalline structure are the most promising ones. $ZnGa_2O_4$ prepared by a simple method of ceramic sintering [6] belongs to this class of materials. For practical application it is necessary to study the radiation properties of this material in detail. In this contribution results of photoluminescence (PL) spectra investigation at temperature of 295 and 10 K are presented.

Sample preparation and experimental methods

The method of preparation of pressed $ZnGa_2O_4$ samples was developed and described earlier [6]. The peculiar feature is that platelets of the material were placed on MgO substrates and annealed. The compound was obtained with normal spinel structure, O_h^7 (Fd3m) space group with the parameter a = 8.34 Å. The experimental equipment for photoluminescence measuring possesses high resolution (±0.1 nm) and allows to perform measurements in the temperature range (10 – 300 K). Radiation excitation was made using Ar laser (λ = 334 nm). In detail the experimental technique is described in papers [7,8].

Results and discussion

The PL spectra of the compound measured at 295 and 10 K are shown in Fig. 1. They contain peculiarities in the range of 350-800 nm. For the first time a wide blue-green PL band has been found out with its maximum at 480 nm, the halfwidth $\Delta h\nu$ = 0.67 eV (T = 295 K) and temperature coefficient $dE/dT = 6.5 \times 10^{-4}$ eV/K. An intensive red band with its maximum at 697 nm (T =295 K) and halfwidth $\Delta h\nu$ = 0.15 eV has been approximated in the range of 680 – 730 nm. As can be seen in Fig. 2 (a, b), these spectra contain a series of sharp peaks, the most pronounced among them are peaks at 687, 695, 708 and 714 nm. Hence, the PL spectra are rich in peculiarities. Most likely, the first band is due to the defect compound structure or ZnO trace amounts. The sharp peaks appear due to impurities of rare-earth elements. More reasonable elucidation of the bands may be made if the samples are obtained

specially doped with ZnO and rare-earth impurities and their PL be studied. X-ray induced luminescence studied previously in this compound [6] has revealed a light emission with its maximum near 590 nm (T = 295 K), that may experience a wide-range shift dependent on the excitation conditions. According to paper [9], the $ZnGa_2O_4$ forbidden gap E_g = 3.0 eV at T = 295 K.

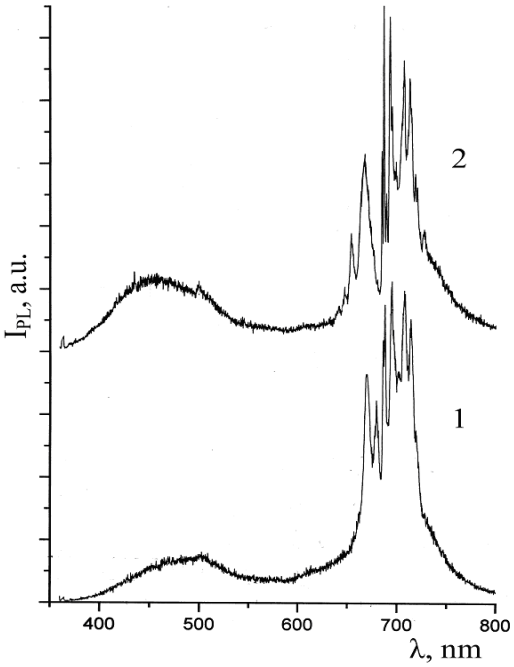

Fig. 1. $ZnGa_2O_4$ PL spectra in the 350-800 nm range: 1 - 295 K, 2 - 10 K.

If we compare the data with PL studies in similar $ZnIn_2S_x$ compound [10], we can attribute the blue-green PL band to the donor-acceptor recombination. The proposed interpretation is also based on the PL investigations published in [9,11]. An intensive band with maximum at 682 nm (T = 295 K) has been found out in the photoluminescence spectra of Eu and F doped luminophor $ZnGa_2O_4$ that may be ascribed to the Eu^{3+} intracentre transition $^5D_0 \rightarrow {}^7F_4$. In paper [11] results are presented about investigation of PL in single crystals of this material doped with Co grown by the Czochralski technique. In the PL spectra a band with peak at 680 nm (T = 295 K) has been found out due to transitions in Co^{2+} ions. Such comparison is possible if we take into account that materials are grown using different methods and impurities.

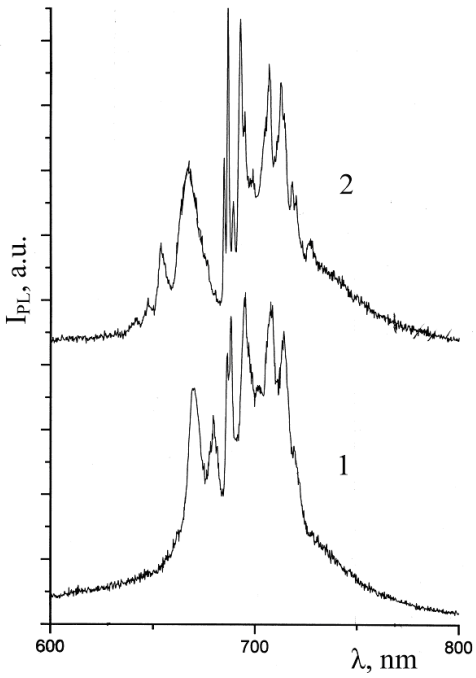

Fig. 2 a. $ZnGa_2O_4$ PL spectra in the 600-800 nm range: 1 - 295 , 2 - 10 K.

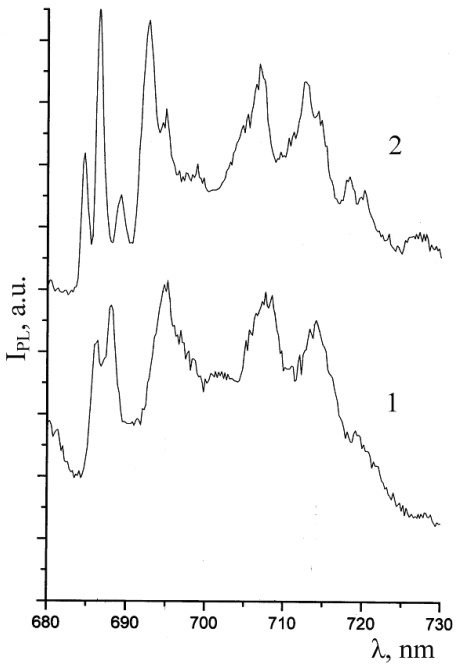

Fig. 2 b. $ZnGa_2O_4$ PL spectra in the 680-730 nm range: 1 - 295 , 2 - 10 K.

The sharp PL peaks at 615, 595 and 584 nm for $ZnGa_2O_4$:Eu and at 639, 656 and 670 nm (T = 77 K) for $ZnGa_2O_4$:Co have been registered [11]. Numerical characteristics are given in the table below.

Table. Parameters of the $ZnGa_2O_4$ PL bands (T = 295 K)

Peaks, nm	Halfwidth, eV	Samples
480	0.67	As-grown ceramics
697	0.15	
659	0.12	Co-doped single crystal [11]
682	0.14	Eu, F-doped luminophor [9]

Conclusion

In conclusion note that the PL peculiarities in the visible range were observed for the first time in nanostructured $ZnGa_2O_4$ samples obtained by the simple method. They have been compared with similar data, and an interpretation possible at the given stage of research has been provided. The way how to change these peculiarities has been shown.

References

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